Wide Area Recovery & Resiliency Program
(WARRP)

Interim Clearance Strategy for Environments Contaminated with *Hazardous Chemicals*

July 2012

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
01 JUL 2012	**Final**	**01 Feb 2010 - 01 Jul 2012**

4. TITLE AND SUBTITLE
Wide Area Recovery and Resiliency Program (WARRP) Interim Clearance Strategy for Environments Contaminated with Hazardous Chemicals

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
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5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
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8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
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10. SPONSOR/MONITOR’S ACRONYM(S)
DHS

11. SPONSOR/MONITOR’S REPORT NUMBER(S)
2.6.0

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release, distribution unlimited

13. SUPPLEMENTARY NOTES
The original document contains color images.

14. ABSTRACT
This document provides a framework for Federal, state, territorial, tribal, and local government officials to use in expediting decisions for characterizing and cleaning up after a wide area hazardous chemical release. Hazardous chemicals include chemical warfare agents (CWAs) and toxic industrial chemicals (TICs), with some TICs considered as potential CWAs. The effort required the development of acceptable clearance criteria for the eventual re-occupancy of the impacted areas. To this end, a Federal interagency group of experts surveyed the current state-of-the-science on risk assessment, sampling analysis strategies, laboratory capacity, decontamination technologies, regulatory environment, and operational logistics as it relates to the development of a chemical clearance strategy. This interim strategy is complementary to the broader overarching White House Office of Science and Technology Policy (OSTP) draft document, Cleanup Decision-Making Guidance for Chemical Incidents. Practical clearance criteria will reduce residual risks to levels acceptable to the Incident/Unified Command. These criteria are incident and site specific, therefore the approach that this framework will take is to define a strategic methodology by which these incident and site-specific clearance criteria are developed. This interim framework is suggested as a living document that will be updated as needed to reflect the state of the science and policy.

15. SUBJECT TERMS
WARRP, Hazardous Chemicals, Toxic Industrial Chemicals, Chemical Warfare Agents, Clearance Strategy, Remediation

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**12**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Purpose:

This *Interim Clearance Strategy for Environments Contaminated with Hazardous Chemicals* document provides a framework for Federal, State, Territorial, Tribal, and local government officials to use in expediting decisions for characterizing and cleaning up after a wide area hazardous chemical release. The effort will require the development of acceptable clearance criteria for the eventual re-occupancy of the impacted areas. To this end, a Federal interagency group of experts surveyed the current state-of-the-science on risk assessment, sampling analysis strategies, laboratory capacity, decontamination technologies, regulatory environment, and operational logistics as it relates to the development of a chemical clearance strategy. Practical clearance criteria will reduce residual risks to levels acceptable to the Incident/Unified Command (IC/UC). These criteria are incident- and site-specific, therefore the approach that this framework will take is to define a strategic methodology by which these incident- and site-specific clearance criteria are developed. This interim framework is suggested as a living document that will be updated as needed to reflect the state of the science and policy. Hazardous chemicals include chemical warfare agents (CWAs) and toxic industrial chemicals (TICs), with some TICs considered as potential CWAs.

General Clearance Approach:

The overall approach to achieving clearance (a determination that cleanup is not required or that cleanup has met the requirements necessary for re-occupancy) is risk-based. Risk assessment tools have been developed by a variety of government agencies to evaluate threats to exposed populations. Risk assessment informs the risk management process, which integrates public health, political, social, economic, engineering, and other considerations into the response decisions. Risk assessment can be initiated at different phases of the response and can be tailored to quantify and evaluate risk to different groups for different purposes (e.g., clearance versus temporary re-entry). Although detailed, site-specific quantitative estimates of risk can be derived using data gathered during the response, qualitative risk assessments can also be developed through comparisons of measured environmental chemical concentrations to benchmarks of toxicity and exposure (i.e., pre-calculated, health-based exposure guidelines). **Although the clearance approach outlined by this document is site- and situation-specific, the overall goal is to define a process where clearance criteria are protective of human health and the environment and permits unprotected re-entry and re-occupancy.** Figure 1 proposes components of a process that may be used for the development of clearance criteria. Adherence to these processes can guide decision makers to develop appropriate clearance goals that are protective of human health and the environment that are cost and time effective. The process for determining clearance criteria following an incident should balance relevant factors, including:

- Health-based human health exposure guidelines;
- Areas affected (e.g., size, location relative to population);
- Types of contamination (e.g., CWA, TIC);
- Other hazards present; (e.g., fires, floods, other chemical/physicals hazards)
- Public welfare;

- Ecological risks;
- Actions already taken and decisions made during crisis management to protect public health and the environment;
- Projected land use;
- Preservation or destruction of places of historical, national, or regional significance;
- Technical feasibility, including:
  - analytical capability and capacity to support clearance goals,
  - ability to apply decontamination options to events of varying scale,
  - ability of field screening instruments to detect contaminants at operationally useful levels;
  - surfaces, media and material resistant to currently available decontamination technologies
- PPE requirements and safety requirements for cleanup workers;
- Processes to identify and construct temporary staging areas so that waste management activities are removed from the critical path of remediation;
- Wastes generated, treatment/disposal options and costs, and strategies and methods to characterize the waste;
- By-products, degradates and undesirable consequences of decontamination options;
- Costs and available resources to implement and maintain remedial options;
- Potential adverse impacts of remedial options to, e.g., human health, environment, economy;
- Long-term effectiveness;
- Timeliness;
- Public acceptability, including local cultural sensitivities; and
- Economic effects (e.g., tourism, business, and industry, denial of access).

Integral to the development of a clearance strategy is the effective management of wastes generated during decontamination, disposal and remediation activities. Temporary and permanent waste management options must comply with all Federal, state and local regulations and ordinances[1]. Laboratory capacity and capabilities will also be critical. Laboratories will need to provide timely analytical results at or below the site specific health-based concentrations levels in order to verify that decontamination and remediation actions have met the clearance criteria. As noted above, the assessment and management of risk is the central focus of any response to the release of hazardous chemicals. However it must also be noted that an integral part of the overall management of human health risk is risk communication. The planning and implementation of a risk communication strategy that bridges the events from crisis to consequence management is paramount to ensuring public understanding and trust which will contribute to the overall success of the response. A single authoritative source of frequent, clear and concise risk communication messages to the public will be necessary during all phases of the incident response.

[1] If the response action is pursuant to CERCLA and on-site, federal and state requirements, but not local, need to be taken into account through the ARARs process.

Flexible Clearance Approach

Clearance decision-making should not be static and prescriptive; rather it should involve a flexible process that includes situation-specific considerations and the most current understanding of science and engineering. A flexible process is needed in which numerous factors are considered to achieve an end result that balances health risks, local needs and desires, costs, technical feasibility, and other factors.

The goals of a clearance decision-making process are:

1. Transparency – The basis for cleanup and other decisions should be available to stakeholder representatives, and ultimately to the public at large
2. Inclusiveness – Representative stakeholders should be involved in decision-making activities
3. Effectiveness – Technical subject matter experts should analyze remediation options, assess various technologies in order to assist in decisions that are optimal for the incident, and consider clearance decisions and clearance goals
4. Shared Accountability – The final decision to proceed will ultimately be made at the local level. In a unified command, with Federal, State, Tribal, and local officials involved in the decision making process, accountability will be shared.

A flexible clearance approach can include consideration of a variety of dose and/or health benchmarks (e.g., advisory levels, clearance goals, etc.), from Federal, State, or other sources (e.g., national and international advisory organizations). These benchmarks may also be useful in analyzing cleanup options. Acute inhalation exposure guideline values could be used when developing health benchmarks for temporary re-entry, while chronic inhalation exposure guideline values could be used when developing health benchmarks for final clearances (Table 1). Figure 2 depicts a side by side comparison of the various inhalation exposure guideline values for Sulfur Mustard at different time frames. Benchmarks derived for shorter or longer exposure durations may be appropriate depending on application, site-specific circumstances or to balance other relevant factors such as technical feasibility. A flexible clearance process provides an opportunity for decision-makers to involve stakeholders and build public confidence in the decision-making process.

Health-based Exposure Guidelines

Many agencies have developed a variety of environmental, health-based exposure guidelines. These guidelines estimate the potential health risks due to exposures by way of inhalation, ingestion or dermal contact from various contaminated matrices for specified periods of exposure. Exposure periods range from acute exposure, typically less than 24 hours, to intermediate exposures lasting up to 7 years, to lifetime or chronic exposures. For example, the EPA has developed health-based Provisional Advisory Levels[2] (PALs), which are threshold inhalation and oral exposure levels for 24-hour, 30-day, 90-day and 2-year exposure durations, for hazardous chemicals. PALs are intended to be used, at the discretion of risk managers in emergency situations, as a means to assist in making informed risk management decisions for

[2] Adeshina, F. et al., Health-based Provisional Advisory Levels (PALs) for Homeland Security, *Inhalation Toxicology*, 2009(S3) 12-16

determining resumed use of infrastructure and temporary re-entry into affected areas. Table 1 summarizes various acute, intermediate and chronic inhalation exposure guidelines, including the inhalation PALs. Table 2 summarizes environmental screening and exposure guidelines for drinking water, soils and surfaces (dermal contact). **Despite numerous standards and regulatory guidelines, there are no predetermined cleanup approaches or levels that are universally applicable to every chemical release incident.**[3] Therefore, coordination among Federal, State, Territorial, Tribal and local governments is critical to ensure the cleanup process is acceptable, effective and yet flexible enough to ensure all the considerations of site-specific characteristics of the particular event are met. These challenges can be addressed by planning ahead, understanding organizational roles and responsibilities, and developing a defined, well-organized and agreed-upon approach to hazardous chemical cleanup decision-making.

Characteristics of Contaminants and Contaminated Areas.

Cleaning up hazardous chemical incidents effectively requires a clear understanding of the contaminant toxicity, concentration, extent of contamination, key physical and chemical characteristics, sources of exposure, routes of exposure, the persistence of the chemical hazards, reactivity (synergistic or antagonistic) with substrate matrices of other substances, as well as the prevailing environmental conditions and characteristics of the media impacted by the specific hazardous chemical incident. Many hazardous chemicals may yield toxic and persistent break down products, or degradates, as a result of interactions/contact with environmental media or the chemical products used for decontamination. The toxicity of and potential exposure to these degradates must be accounted for in any overall site clearance decision such that the risk to the environment and public safety is not compromised. A series of two-page Quick Reference Guides (QRG) that describes selected CWA/TIC characteristics, physical and chemical parameters, possible release scenarios, health effects, personnel health and safety, field detection, sampling and analysis, decontamination and waste disposal are available from the National Response Team website (http://www.nrt.org/).

Key physical and chemical parameters include:

- Vapor pressure, vapor density, and volatility;
- Freezing/melting point and boiling point;
- Solubility in water and other solvents;
- Octanol-water partition coefficient (Log K_{ow});
- Henry's Law Constant;
- Flash Point;
- Reactivity with ultraviolet (UV) light, water, oxidizers, and other decontamination agents;
- Propensity for chemical adsorbtivity and/or physical adsorption; and
- Persistence and environmental fate.

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[3] If the response to the release is pursuant to CERCLA, then the National Contingency Plan applies.

Key environmental conditions include:

- Ambient temperature;
- Relative humidity;
- Sunlight levels;
- Wind/ air flow; and
- Topographical relationship to release point and intervening terrain and structures.

Key media characteristics include:

- Porosity (porous/non-porous);
- Organic/inorganic content;
- Time exposed to contaminant(s);
- Reactivity-interactions w/ agents; and
- Sensitive items/historical/cultural significance items.

The judicious use of the knowledge on the prevailing environmental conditions, agent characteristics and impacted surfaces and media can assist planners in directing samplers to the most advantageous areas for characterization and clearance sampling, selecting the most efficacious decontamination methods as well as assisting the risk assessors in determining the most appropriate site-specific clearance goals.

Pre-clearance Re-entry Values

The different phases of the overall remediation process will require temporary re-entry by responders or others. Although not classified as clearance, a similar process can be applied to derive risk-based exposure guidelines to inform decision-makers at various phases of the remediation for differing periods of time. An example of this would be a temporary re-entry exposure guideline established for responders during characterization or decontamination activities to allow site workers to accomplish specific tasks at exposure levels above that designed for clearance, while working in appropriate PPE with site monitoring. Numerous environmental screening or exposure values exist for CWAs that can be used to determine pre-clearance re-entry values (Tables 1 and 2). Selection of temporary re-entry monitoring levels or final clearance goals may include quantitative and qualitative assessments applied at each stage of site restoration decision-making from evaluating cleanup options through implementing the chosen cleanup alternative.

Challenges of Clearance for Wide Area Contamination

Wide area contamination from the deliberate release of hazardous chemicals, including CWAs and TICs, will present unique challenges. The varieties of terrains, environments, public spaces and materials impacted will necessitate a tiered approach toward remediation, as well as a flexible clearance process. Limited analytical capacity, decontamination assets and environmental exposure guideline values on all the possible impacted media may necessitate

novel approaches to sampling, analysis, decontamination and clearance. **These procedures must be agreed upon at the highest levels in the Incident Command structure and be clearly and concisely communicated to the public for a successful remediation and recovery to occur.**

A variety of health based values can be used to evaluate exposures for emergency response phase. Exposure guidelines for short and longer-term exposure durations can be used to evaluate occupational and general public health exposures in the remediation and recovery phases, for air, soil and water matrices. These environmental exposure guideline values have been developed by various agencies. The IC/UC Clearance Committee may use these data the basis for developing site- and situation-specific clearance goals. Target population, exposure duration, intended application and level of peer-review are some of the factors that should be considered in choosing appropriate exposure guideline values. No single value will be suited for every chemical or situation, but they provide a starting point for site-specific considerations. Ultimately, it is important to clearly understand what these values represent and what they do not represent so that they are used appropriately. And, if an available value does not adequately reflect the site- and situation-specific nature of the scenario, an experienced toxicologist should be consulted to derive a *de novo* site-specific exposure guideline.[4]

Challenges of Clearance for Indoor-Outdoor Surfaces

Wide area contamination events resulting from accidental or intentional releases of CWA and/or TICs are expected to yield substantial contaminated surface areas that would pose a dermal contact hazard to the general public. Surfaces from both urban and rural areas present a vast array of materials with differing affinities for the hazardous chemical to which they are exposed. Both indoor and outdoor surfaces may present both acute and chronic exposure risks, especially in common public areas such as transportation hubs, sporting/entertainment venues, schools, hospitals, as well as private residences and municipal/governmental buildings. This will challenge the risk assessor/toxicologist in their determinations of exposure and risk to the public. There are currently no peer-reviewed, published values for short- or long-term dermal exposures. Quantitative risk-based methods apply oral toxicity values to assess risks from dermal exposure. Depending on the studies from which a chemical's toxicity value was derived, one may need to adjust the oral toxicity value from an administered dose to an absorbed dose. The methodology is provided in EPA's Risk Assessment Guidance for Superfund (RAGS).[5] More recently, the EPA has recognized the need to expand its efforts to include building surfaces. Subsequent to the attack on the World Trade Center, the EPA became involved in efforts to develop risk-based surface cleanup goals (EPA, 2003)[6] using methodology similar to that provided by RAGS Part B. The World Trade Center model incorporated into the newest edition of the RAGS, Part E, Supplemental Guidance for Dermal Risk Assessment. Other methods for the derivation of surface cleanup goals are currently under consideration. The California EPA (CAL EPA) has recently incorporated EPA's Stochastic Human Exposure and Dose Simulation (SHEDS) Model used for determining the exposure risks from clandestine methamphetamine drug laboratory, to

[4] U.S. EPA, 1991, Risk Assessment Guidance for Superfund: Volume I: Human Health Evaluation Manual (Part B, Development of Risk-based Preliminary Remediation Goals). EPA/540/R-92/003.

[5] See Chapter 4 of the EPA's *Risk Assessment Guidance for Superfund (RAGS)*, Volume I: Human Health Evaluation Manual (Part E, Supplemental Guidance for Dermal Risk Assessment, Interim (2004), available at http://www.epa.gov/oswer/riskassessment/ragse/

[6] US EPA 2003, World Trade Center Indoor Environmental Assessment: Selecting Contaminants of Potential Concern and Setting Health-based Benchmarks. Prepared by the Contaminants of Potential Concern (POPC) Committee of the World Trade Center Indoor Air Task Force Working Group

estimate the dermal exposures from surface contact with hazardous chemicals, including CWAs.[7] The CAL EPA modified SHED model has yet to be adequately validated but may provide a platform, along with EPA RAGS methodologies, to develop site- and incident-specific clearance goals for contaminated surfaces.

[7] See http://www.oehha.ca.gov/public_info/public/pdf/ExpoAna122807.pdf

Table 1 – Inhalation Exposure Guidelines for Selected CWAs

Guideline	Duration (hr)	**Sarin** (mg/m^3)	**Sulfur Mustard** (mg/m^3)	**Lewisite** (mg/m^3)	**VX** (mg/m^3)
IDLH[1]	0.5	0.1	0.7	NA	0.003
STEL[1]	0.25	0.0001	0.003	NA	0.00001
AEGL-1[2]	0.17	0.0069	0.4	NA	0.00057
AEGL-1	0.5	0.004	0.13	NA	0.00033
AEGL-1	1	0.0028	0.067	NA	0.00017
AEGL-1	4	0.0014	0.017	NA	0.00010
AEGL-1	8	0.001	0.0083	NA	0.000071
AEGL-2	0.17	0.087	0.6	NA	0.0072
AEGL-2	0.5	0.05	0.2	0.23	0.0042
AEGL-2	1	0.035	0.1	0.12	0.0029
AEGL-2	4	0.017	0.025	0.035	0.0015
AEGL-2	8	0.013	0.013	0.018	0.0010
AEGL-3	0.17	0.38	3.9	3.9	0.029
AEGL-3	0.5	0.19	2.7	1.4	0.015
AEGL-3	1	0.13	2.1	0.74	0.010
AEGL-3	4	0.07	0.53	0.21	0.0052
AEGL-3	8	0.051	0.27	0.11	0.0038
PAL-1[3]	24	0.0002	0.0008	NA	0.000017
PAL-1	720	0.000018	0.0001	NA	0.0000018
PAL-1	2160	0.000018	0.0001	NA	NA
PAL-2	24	0.001	0.013	0.01	0.00063
PAL-2	720	0.00073	0.0029	NA	0.000073
PAL-2	2160	0.0002	0.00097	NA	NA
PAL-3	24	0.015	0.35	0.037	0.0022
PAL-3	720	NA	NA	NA	NA
PAL-3	2160	NA	NA	NA	NA
MRL acute [4]	24	NA	0.0007	NA	NA
MRL acute	336	NA	0.0007	NA	NA
MRL intermed.	360	NA	0.00002	NA	NA
MRL intermed.	8760	NA	0.00002	NA	NA
WPL	8760	0.00003	0.0004	NA	0.000001
WPL[1]	219000	0.00003	0.0004	NA	0.000001
GPL	8760	0.000001	0.00002	NA	0.0000007
GPL[1]	613200	0.000001	0.00002	NA	0.0000007

NA = not available

[1] Chemical Exposure Guidelines - available at http://cdc.gov/NIOSH/ershdb/index_name.htm

[2] Acute Exposure Guideline Levels (AEGLs) – available at http://www.epa.gov/opptintr/aegl/

[3] Provisional Advisory Levels (PAL) – available at http://www.epa.gov/nhsrc/index.html

[4] ATSDR Minimal Risk Levels (MRL) – available at http://www.atsdr.cdc.gov/mrls

Table 2 - Environmental Screening and Exposure Guidelines for Selected CWAs					
Drinking Water - (µg/L)	Duration	Sarin	Mustard	Lewisite	VX
RBC [1]	Lifetime	0.7	0.25	3.5	0.021
MEG 5L/day [2]	7 years	28	140	28	15
MEG 15L/day	7 years	9.3	47	27	8
PAL-1 2L/day [3]	1 day	37	NA	NA	2.7
PAL-1 2L/day	30 days	8.1	NA	NA	0.21
PAL-1 2L/day	90 days	2	NA	NA	0.21
Soil - (mg/kg)	Duration	Sarin	Mustard	Lewisite	VX
PRG – Residential [4]	Lifetime	1.3	0.01	0.3	0.042
PRG – Industrial	24 years	32	0.3	3.7	1.1
Surface - ($\mu g/cm^2$)	Duration	Sarin	Mustard	Lewisite	VX
PRG Residential [5]	Lifetime	4.3×10^{-3}	8.1×10^{-5}	6.0×10^{-2}	1.3×10^{-4}
PRG Occupational	24 years	1.2×10^{-2}	2.2×10^{-4}	2.0×10^{-2}	3.6×10^{-4}

[1] Risk Based Criteria (RBCs) - values calculated for chronic exposure calculated akin to EPA's Maximum Contaminant Levels (MCLs), see: http://water.epa.gov/drink/contaminants/index.cfm

[2] Military Exposure Guidelines (MEG), The Medical NBC Battle Book, Technical Guide 244, USACHPPM, 2008

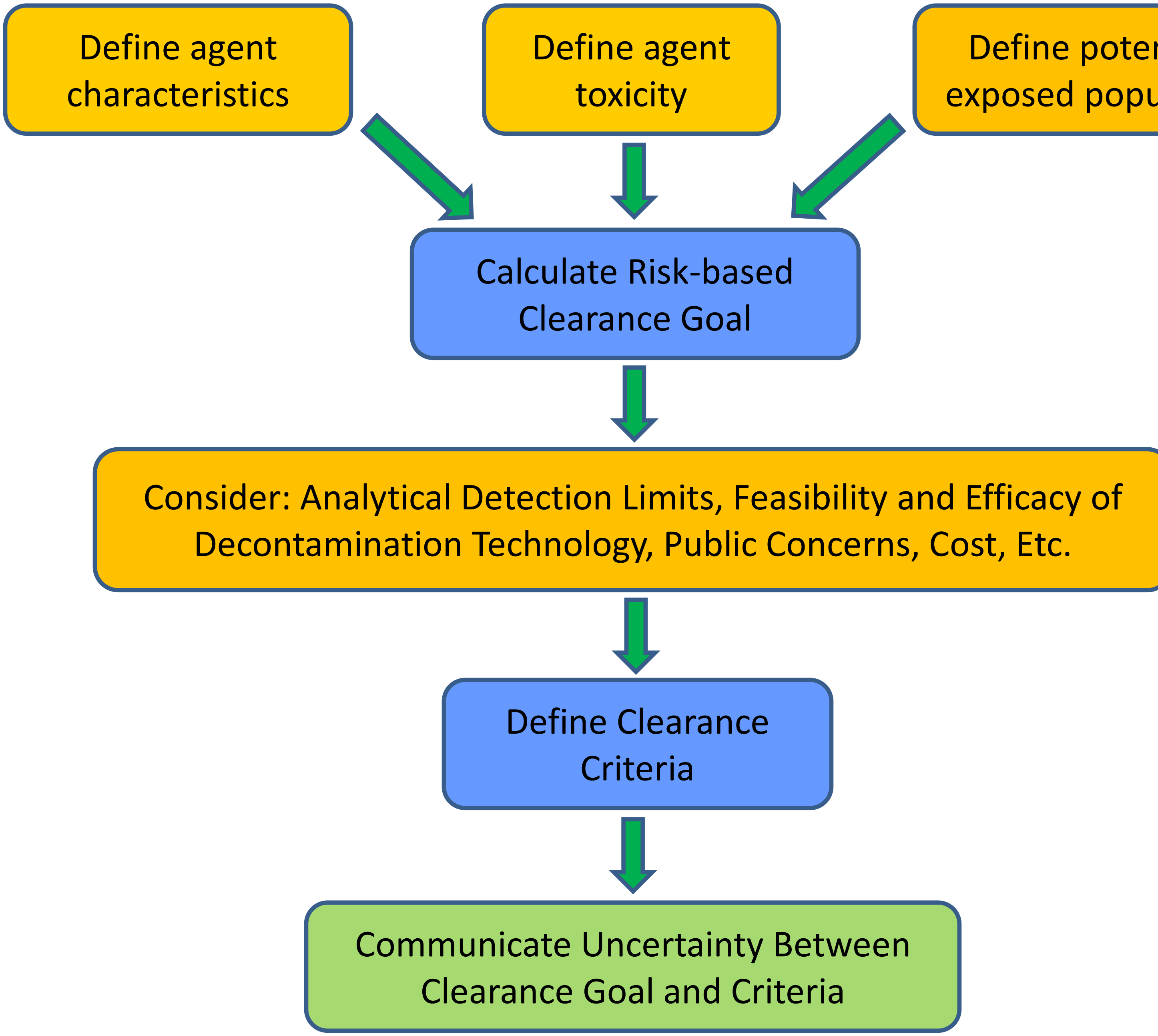
[3] Provisional Advisory Levels, no adverse effects (PAL-1) - available at http://www.epa.gov/nhsrc/index.html

[4] Preliminary Remediation Goals (PRG) risk based goals for soils - available at http://www.epa.gov/reg3hwmd/risk/human/rb-concentration_table/index.htm

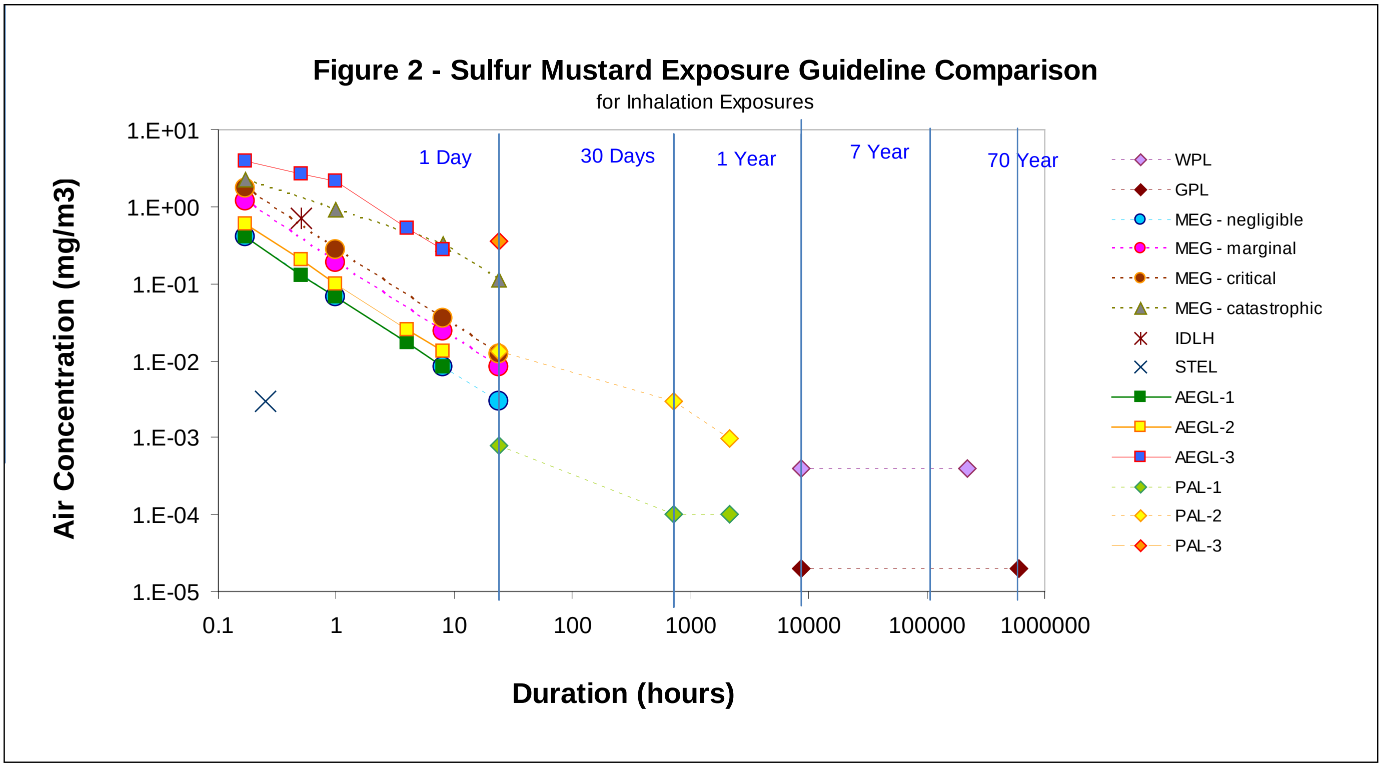
[5] Preliminary Remediation Goals (PRG), risk based goals for surfaces calculated via EPA's Risk Assessment Guide for Superfund (RAGS) methodologies, available at http://www.epa.gov/oswer/riskassessment/ragse/

NA = not available due to rapid decomposition of agent in water

Figure 1. Proposed Clearance Process



[8]



WPL = Worker Population Limit

GPL = General Population Limit

MEG = Military Exposure Guideline

IDLH = Immediately Dangerous to Life and Health

STEL = Short-Term Exposure Limit

AEGL = Acute Exposure Guideline Level

PAL = Provisional Advisory Level

[8] USAEP 2009, Graphical Arrays of Chemical-Specific Health Effect reference Values for Inhalation Exposure, EPA/600/R-09/061, September 2009